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Track Initiation Techniques in a Dense Detection Environment

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In a dense detection environment, current track-while-scan algorithms will inevitably introduce false tracks when processing is performed on a scan-by-scan basis. Four track-initiation techniques are discussed and evaluated against three typical raid scenarios. Three of the techniques are within the current state of the art. The fourth technique is the maximum likelihood solution for track initiation which involves enormous computational requirements. This technique is included to provide a standard of comparison for the other techniques. The other three techniques are the conventional nearest neighbor correlator with an a priori velocity, a raid initiator in which firm tracks are removed

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20. Abstract (Continued)

from a raid as soon as a good velocity estimate is obtained, and a raid tracker in which individual tracks are operated on as a raid while the estimates of raid velocity and size are refined. The preferred technique would seem to be the raid tracker.

CONTENTS

TRACK INITIATION TECHNIQUES
IN A DENSE DETECTION ENVIRONMENT

1. INTRODUCTION

Track-while-scan systems were first proposed for surveillance radars during the 1950's. If the probability of detection per scan is high, if accurate measurements are made, if the target density is low, and if there are few false detections, the design of the correlation logic and tracking filter is straightforward. However, in a realistic radar environment these assumptions are never valid, and the design problem is complicated. This report will consider the problem of track initiation in a dense detection environment. Since angle resolution is much poorer than range resolution, only range information will be utilized in this study.

In Fig. 1, there are three tracks and each track is detected five times. While it is obvious that there are three tracks present, many tracking systems would initiate incorrect tracks because they only associate the nearest detection with the predicted position of a tentative track, and such position prediction with only one detection depends on an assumed velocity. Moreover, the situation in Fig. 1 rarely occurs; the situation in Fig. 2 is more common. Figure 2 shows the same three tracks; however, several detections have been merged (i.e., individual targets are not resolved), three detections are missing, and two false alarms have been introduced.

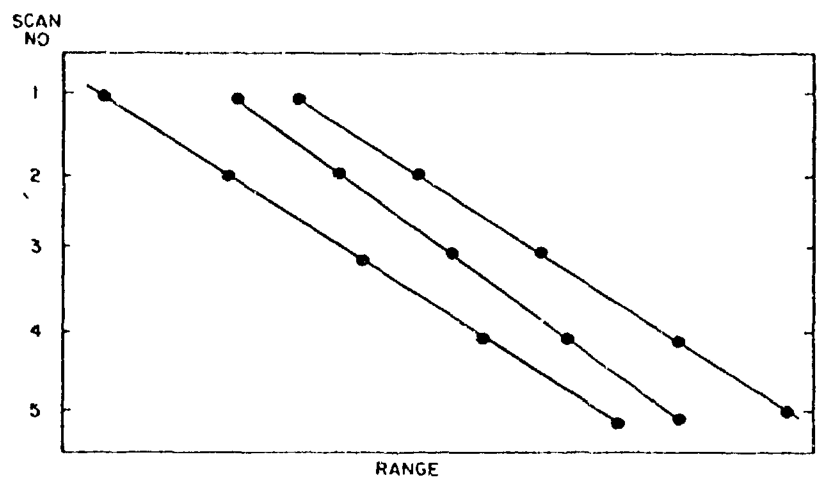

Fig. 1 — History of five scans of three tracks showing all detections present

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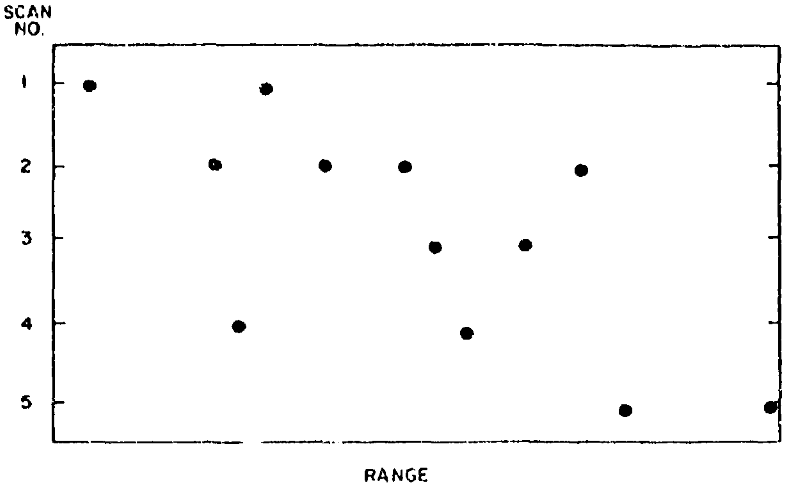

Fig. 2 — History of five scans in which detections were missed, detections were merged, and false alarms occurred

The optimal solution of such problems has been generated under ideal conditions. Specifically, the maximum-likelihood solution has been developed under the assumptions that the probability of detection, the probability of false alarm, the probability of target resolution as a function of target separation, and measurement error characteristics are all known a priori and that all targets are moving in straight lines. (A somewhat similar approach was used by Stein and Blackman [1]; however, they did not consider resolution problems.) Even if all of the above assumptions were true, the maximum-likelihood method cannot be implemented in the foreseeable future because of the enormous computational load. However, it is still useful because it provides a standard with which to compare algorithms that can be more readily implemented.

This report is principally concerned with three techniques which are feasible with current equipment. These techniques of handling raids will be compared with the maximum-likelihood estimate method of initiating tracks on four-target raids in three different scenarios. The three techniques are the conventional Nearest Neighbor Correlator (NNC) with an a priori velocity estimate for initiation as in MERIT [2], a Raid Initiator (RI), and a Raid Tracker (RT). These techniques will be discussed in greater detail in Section 2.

The three scenarios are a long-range threat, a pop-up threat where the targets are not always resolved, and a pop-up threat where the targets are nearly always resolved. The scenarios and data generation are discussed in Section 3.

2. DISCUSSION OF TECHNIQUES

Maximum-Likelihood Initiation

The Maximum-Likelihood Initiation (MLI) has previously been documented in the literature [3]. The maximum-likelihood method involves calculating the total probability that a given set of detections correctly represents a specified set of tracks. The probability of detection, the probability of false alarm, the probability of target resolution as a function of target separation, and the measurement error characteristics are all taken into account in the likelihood. To facilitate the mathematical description of the likelihood method the following terms and definitions are used:

N_S = number of scans,

N_T = number of tracks,

N_D = total number of detections,

N_{FA} = number of false alarms,

N_M = number of missed detections associated with the N_T tracks,

N_{DR} = number of detections involved in resolution problems (i.e., number of detections used in at least two tracks),

$N_{TR}(k)$ = total number of tracks using the kth detection which is used in at least two tracks,

x_{ij} = range of detection associated with ith track on the jth scan. If there is no detection associated (i.e., track has a miss associated), $x_{ij} = 0$, and

y_{ij} = predicted range of the ith track on jth scan, assuming a straight-line trajectory.

The likelihood of an N_T track combination is given by the following:

$$L(N_T) = P_{FA}(N_{FA}) \cdot$$

$$\binom{N_S N_T}{N_M} (P_D)^{N_S N_T - N_M} (1-P_D)^{N_M} \cdot$$

$$\left[\frac{1}{(2\sigma^2)^{1/2}}\right]^{N_S N_T - N_M - N_{TR}} \prod_{i=1}^{N_T} \prod_{j=1}^{N_S} f(x_{ij} - y_{ij}) \cdot$$

$$\prod_{k=1}^{N_{DR}} P_R(x_k)\, P_e(x_k) \cdot$$

$$(F_R)^{N_{TR} - N_{DR}} \, (F_M)^{N_M} \; .$$

The first line represents the false-alarm probability based on a Poisson density function P_{FA}; the second line indicates the probability of obtaining a number of detections, given the probability of detection of the radar P_D. The third expression gives the measurement error probability based on Gaussian distributed errors. Line four gives the resolution probability, where $P_R(x_k)$ is the probability that detection x_k is the result of merging the detections of more than one target as a function of the distance between the predicted positions of the targets, and $P_e(x_k)$ is the probability that x_k would occupy the position it does, given that x_k is merged from several detections. The last line involves correction factors F_R and F_M, which penalize tracks that have unresolved detections and tracks with missing detections, respectively. For a mathematical description of the various probabilities see Ref. 1.

One problem with MLI is the computational load. Since search techniques cannot be used to maximize the likelihood functions because of the large number of local maxima, the concept of a "feasible track" was introduced, where a feasible track consisted of a specified number of detections lying within a specified distance of a straight line. Then the maximum likelihood of occurrence of each combination of the feasible tracks was evaluated. If there were N feasible tracks and one was interested in up to M track combinations,

$$\sum_{i=1}^{M} \binom{N}{i}$$

likelihood functions would have needed to be evaluated. For instance, if $N = 30$ and $M = 4$, the number of likelihoods calculated is 31930. For this reason, the MLI is considered only as a standard of comparison for the other techniques.

Nearest Neighbor Correlator

The first technique to be discussed is a conventional Nearest Neighbor Correlator (NNC) with an a priori velocity for initial detections. This type of automatic tracker was implemented on the ADIT (Automatic Detection, Integrated Tracking) system [4,5] and is available as a simulation tool as MERIT [2]. Briefly, the NNC maintains a file of persistent

clutter points and file of tracks which are differentiated into firm tracks and tentative tracks. Starting with the clutter file, then the firm tracks, and then the tentative tracks, detections which correlate with members of these files are used to update those members. Any unused detections are then used to initiate tentative tracks. Each newly initiated tentative track is assumed to have the a priori velocity, and the predicted position for the next detection is calculated accordingly. On each subsequent scan of the radar, the detections remaining in the detection file after the clutter file and the firm tracks have been processed are compared to the predicted position of the tentative track. If no detections are within the correlation region of the track on two consecutive scans, the tentative track is dropped as a false alarm. If one or more detections are inside the correlation region, the detection nearest (in the statistical sense) the predicted position is used to update the track. Tentative tracks are updated by maintaining the smoothed position at the site of the original detection, calculating the velocity based on the positions of the current and the original detections, and predicting the position of the target on the next scan. A tentative track is promoted to a firm track if a detection is associated with it on any scan after the third. This delay ensures at least one intermediate update on the track besides the initial detection and the final detection that makes it firm. Once the targets are made firm, the positions and velocities are smoothed with an α-β filter.

Raid Initiator and Raid Tracker

The Raid Initiator RI and the Raid Tracker RT are adapted from a concept of Flad [6]. The method of identifying a raid is the same as Flad's; the method of tracking a raid and removing tracks from the raid to firm track status differs. One or more tracks are recognized as a raid when there are one or more detections common to the correlation regions around each track. One or more detections are identified as an updating set of detections if they are in the correlation region of a track belonging to a raid. Flad's suggested method of updating the velocity of a raid is to use one of the well-known tracking algorithms such as Kalman filtering or α-β filtering, applied to the mean position of the updating set of detections. The initial estimate of the raid velocity is generated from the mean position of the original detections and the mean position of the first set of updating detections. For computational reasons in this simulation, throughout the life of the raid the mean velocity of the raid is calculated from the *current* position of the updating detections and the original detections of the tracks involved in the raid. The smoothed positions of the tracks involved in the raid are set to the positions of the detections, and the predicted positions of the tracks on the next scan are obtained from these positions using the mean velocity. If there are more tracks than detections involved in a raid, then the excess tracks are coasted from the mean position of the detections. If there are more detections than tracks, then additional tracks are generated from the positions of the excess detections.

The philosophy of the Raid Initiator is to use the raid tracking only to maintain tentative tracks while an adequate velocity estimate is obtained to convert the tentative tracks to firm tracks. An adequate velocity estimate is assumed to have occurred in the following situation: when a tentative track has correlated with a detection in a small correlation region on two successive scans. The correlation region is sized to yield a velocity estimate accurate within approximately 10%.

An alternative philosophy inspired (as we shall see) by the results of the Raid Initiator is the Raid Tracker. In the case of the Raid Tracker we are content to track the raid and refine the estimate of velocity, and estimate the number of tracks N_T by minimizing the cost function

$$C(N_T,P_D) = (\mu - N_T P_D - \lambda)^2 + |\sigma_N^2 - N_T P_D(1-P_D) - \lambda|,$$

where μ and σ_N^2 are the average and variance of the number of detections on each scan, P_D is the probability of detection, and λ is the expected value of Poisson-distributed false alarms. For a given N_T, the value of P_D that minimizes this cost function is

$$P_D = [2\mu - 2\lambda \pm 1]/[2N_T \pm 2],$$

where the appropriate sign depends on whether the term within the absolute value is positive or negative. By specifying a value of λ and limiting the range of P_D, we estimate N_T by choosing the N_T and P_D which yield the smallest cost function.

One further remark is in order: the Maximum Likelihood Initiation and the Raid Tracker are batch processes, i.e., the detections are accumulated for some number of scans, 5 or 10, etc., and some procedure yields information on the tracks present. The conventional Nearest Neighbor Correlator and the Raid Initiator are continuous processes in the sense that only the current set of detections is operated on, by correlating it with some set of tracks which incorporates information from the preceding detections.

3. DATA GENERATION

The Radar Analysis Staff has at its disposal an in-house-developed surveillance radar simulation program SURDET. This simulation is well documented [7,8], but will be briefly discussed here.

SURDET produces radar detections and position estimates for each radar scan. These detections correspond not only to target detections but also to correlated and uncorrelated false alarms. The radar operates within a specified scenario defined by up to 20 targets and jammers in a clutter environment of rain or sea, in addition to multipath propagation. Each target trajectory can take one of three forms: a straight line between the starting point and the endpoint, a straight line in the xy plane with different altitude legs, or a constant-altitude flight with a turn between two straight-line legs.

SURDET has been constructed as a modified time-step model. The time steps involved are determined by the elapsed time between radar scans illuminating the target. The surveillance radar under examination is characterized by its radar scan modes. A radar scan mode is a means of defining radar operating characteristics for the illumination of a specific geometrical region. Typical radar scan modes include elevation beams, long-range search, high-angle low-energy search, burnthrough, and horizon scan. At the onset of the engagement (when the earliest target leaves its initial position), the time when each operational radar scan mode will first illuminate any target is determined. The minimum time minus 30 s is compared to a maximum start time, which is an input value, and the smaller of these two times is used as

the start of the simulation. The additional time before the first possible target detection is necessary for clutter generation for realistic tracking studies.

For each radar scan the signal (target), noise, jamming, and clutter energies are calculated for each target and each radar scan mode. If a target detection is possible (depending on the signal-to-interfering-power ratio), the radar return is simulated pulse-to-pulse in the test cell of interest and in the surrounding reference cells. This level of detail is required in order to take into account the problems of target suppression and target resolution caused by nearby targets. Next, target detections are declared by comparing the test cell of interest to a threshold generated from the surrounding reference cells. Since multiple detections of a single target can occur, such detections are merged into a centroided detection. Finally, the centroided detection is corrupted by the effects of roll and pitch.

The radar simulated is a 3-D L-band radar with a free-space detection range of 370 km (200 n.mi.) on a 1-m^2 target. The adjacent beam positions overlap at about the 2-dB point with a 5-s scan rate. The compressed pulse width is 1 μs, giving a range resolution of nominally 152 m (500 ft). There are only two pulses transmitted on each beam position. This requires the use of a 2 out of 2 (M out of N) detector; that is, when the threshold is generated from the surrounding reference cells, both of the pulses from a beam position must exceed the threshold to declare a detection.

False alarms are generated at the mean Poisson rate of 1.5 false alarms uniformly distributed over a range interval of 148 km (80 n.mi.); this interval is situated over the range interval in which initiation is expected to take place.

Three scenarios are chosen to represent the various situations which might confront a radar with automatic tracking. Each scenario involves four targets following the same trajectory, with various time delays between targets yielding different range spacings for different scenarios.

The first scenario is the far-range scenario in which Mach 3 targets start over the horizon near the effective detection range of the radar (370 km (about 200 n.mi)), climb to 24.4 km (80K ft), and fly directly toward the radar. Even though the two targets in the raid that are closest together are two range cells apart, they are merged by the target centroider about 25% of the time.

In addition to the merging problem, there are missed detections due to low signal-to-noise ratios. Figure 3 displays these features in an eight-scan detection history of the far-range scenario. In this and the following two figures, the range is normalized by removing target velocity, retaining only target spacing and measurement error. *FA* beside a detection indicates a false alarm, *M* indicates a missed detection, a curved line linking positions where detections should be indicates merged detections, and dashed lines indicate the tracks initiated by the Maximum Likelihood Initiator.

The second scenario is the pop-up, resolution scenario where Mach 2 targets pop up at 46.3 km (25 n.mi.), climb to 457 m (1500 ft), then dive back down to 30.5 m (100 ft) and close on the radar. This is called the resolution case because the closest spaced targets

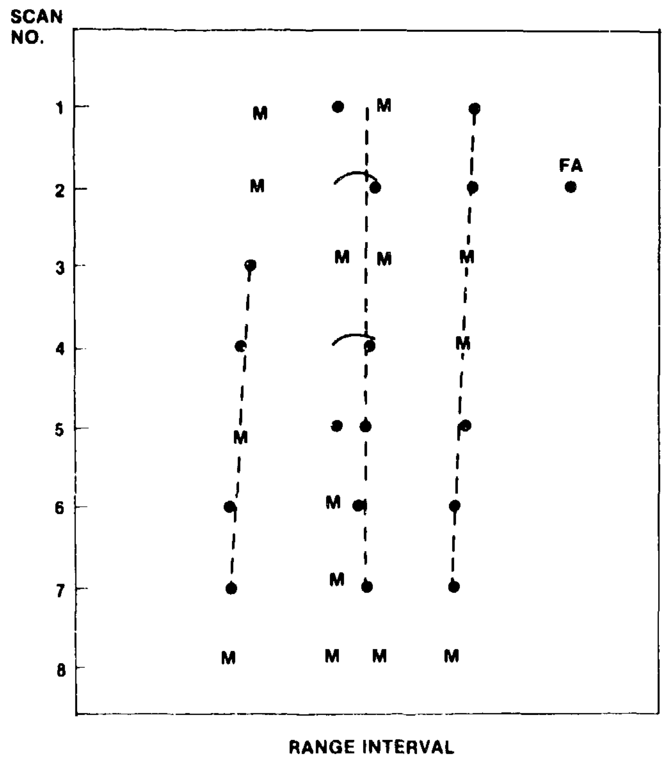

Fig. 3 — Eight-scan detection history of four targets in far-range scenario

are unresolved 66% of the time. These targets are over 2.5 range cells apart, but because of the strong signal (short range), detections occur in range, azimuth, and elevation cells adjacent to the cell containing the target and induce the centroider to merge all detections into one very, very strong target instead of two very strong targets. Notice in Fig. 4 that in scan 2, three targets have been merged into one detection positioned at the center of gravity of the individual detections.

The last scenario is the pop-up, separated scenario which differs from the previous case by a greater separation between targets. The targets are nearly 4 range cells apart and targets are merged on about 20% of the scans. Figure 5 displays the perfect detection history possible in the pop-up, separated scenario. However, notice that detection 1 on the first scan, 2 on the second scan, etc., 4 on the fourth scan are perfectly consistent with a track whose velocity differs from the actual tracks by nearly 20%. The MLI selected the four tracks shown as one thousand times more likely than the case of five tracks, i.e., the four tracks shown plus the extraneous track.

One final remark is appropriate: in a CFAR detector with closely spaced targets, target suppression could be a problem. In this study we assumed that a radar operator would recognize the situation and take appropriate action; i.e., use log video, set the threshold for

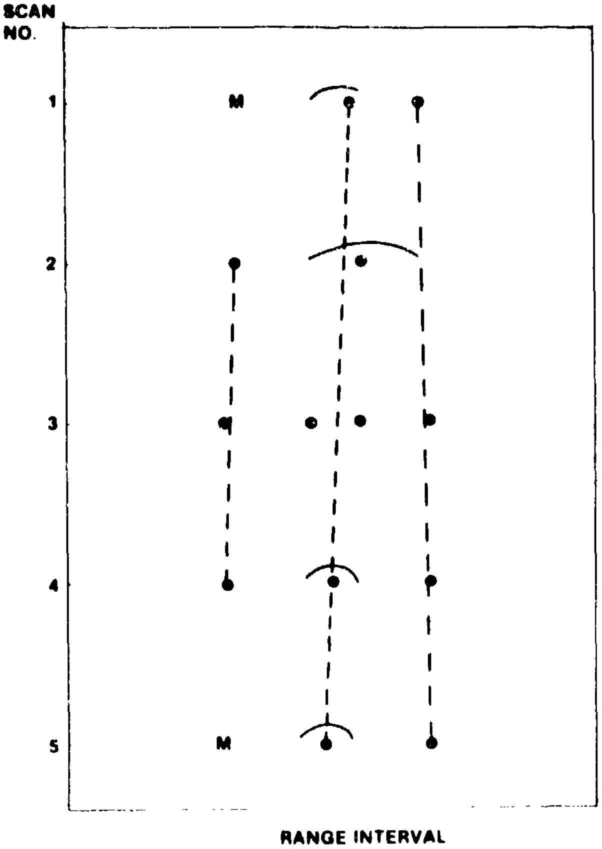

Fig. 4 — Five-scan detection history of four targets in pop-up resolution scenario

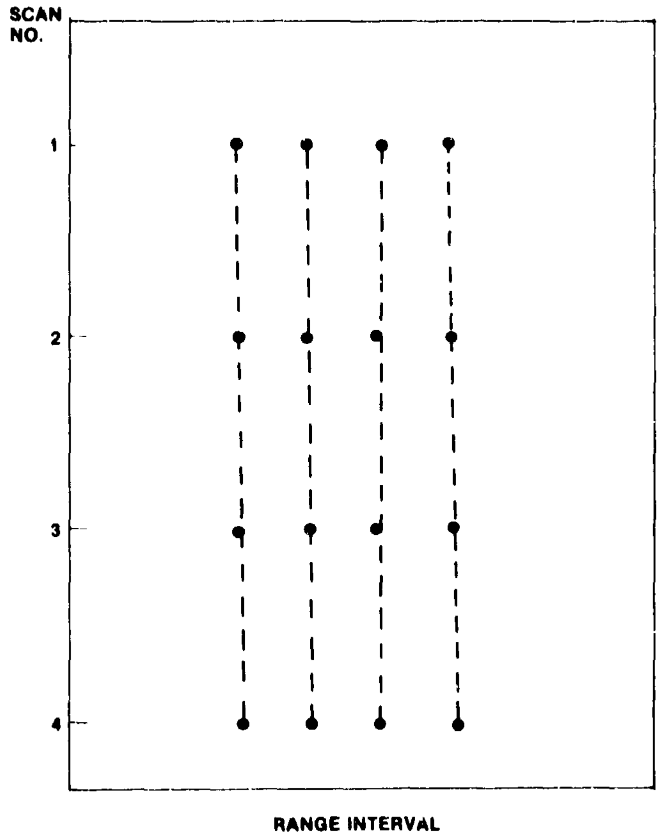

Fig. 5 — Four-scan detection history of four targets in a pop-up, separated scenario

the automatic detector by choosing the set of reference cells with the smaller average value, and use only the mean to calculate the threshold, and not the mean and variance. This particular detector seems to have largely eliminated the target suppression problem. Most missing detections are due to low probability of detection (far-range scenario) or to merging of detections.

4. RESULTS

As a baseline reference, data from a single target following the far-range and the pop-up trajectories were generated in ten repetitions and fed to the conventional a priori tracker to obtain the time required to initiate.

For a target following a pop-up trajectory, detections were obtained every scan and a firm track was declared at the earliest opportunity. This was three scans after the first detection, except in one repetition where the first detection of the target updated a clutter point generated by a false alarm. In another repetition a false firm track was declared based on a combination of false alarms and detections of the target. This false track was dropped at the earliest opportunity.

A target following the far-range trajectory was characterized by a lower probability of detection and fades in signal due to multipath propagation. Even so, in half of the repetitions tracks were made firm at the earliest opportunity. The average delay was 5.5 scans following the initial detection. The average was lengthened by three repetitions where long fades inhibited initiation for as long as 15 scans in one extreme case. In two cases, false tracks were initiated; one case was based on all false alarms and the other on a combination of false alarms and a target detection.

Ten repetitions of each scenario were performed, differing in the random numbers used to determine probabilistic results (target or noise fluctuations, etc.) and in the position of the radar in its scan relative to the raid in its trajectory (so that the raid doesn't come over the horizon at the same time in each repetition).

Because two of the techniques are batch operations and two are continuous operations, there is a difficulty in comparing results. Thus, in an attempt to present the data in a form suitable for meaningful comparisons, the performance tables to follow display two different formats in the same table. For the batch processes, the number of tracks declared when the processor operates on a given number of scans of data is presented. For the pop-up trajectories, the numbers of scans examined are 4 and 5; for the far-range targets the numbers of scans are 6 and 8. This reflects not only the better probability of detection, but the urgency of initiating tracks quickly at the shorter ranges. For the continuously operating processes, the number of scans required to establish a given number of tracks (1, 2, 3, or 4) is presented. Note that this includes the scan in which the target was first detected, because this scan is also counted in the number of scans used by the batch processes. The results are displayed for each repetition of each scenario.

Table 1 displays the results for the far-range scenario. The MLI indicates three tracks on the average. If we examine the detection pattern for the far-range scenario in Table 2,

this seems reasonable; there are many missing detections due to the low probability of detection and erroneous target merging. The RT has a performance comparable to the MLI. The RI and the NNC initiator obtain the first two tracks quickly but require 16-17 scans to obtain the third track. The RI eventually obtains a fourth track in 8 out of 10 cases, but the NNC often initiates one or more false tracks.

When the detailed output of the RI was examined, we found that due to the detection pattern, once the first two tracks were initiated and removed from the raid, the remaining detections were not consistent enough to maintain a raid with a good velocity estimate. This delayed the initiation of the third and fourth tracks and suggested the investigation of the RT in which the good quality tracks weren't removed. As we have seen, the RT compared favorably with the MLI as far as number of tracks is concerned, but no qualitative study was performed on the accuracy of the position and velocity estimates of the tracks obtained in the RT and MLI techniques; the only criterion examined was that valid tracks had velocity errors less than 10% of the true velocity.

Table 3 displays the results for the pop-up resolution problem scenario. Again, the MLI and the RT obtain roughly equivalent results as far as the number of tracks in the raid is concerned, but for best results (correct 80% of the time) we should wait 5 scans. The RI and the NNC perform roughly equivalently with a slight edge to the NNC, but in general obtained only three tracks. The detection pattern in Table 4 indicates an average of three detections per scan on the four targets. The missing detections are absorbed into other detections (targets not resolved).

Table 5 displays the results for the pop-up separated scenario. The MLI gives perfect results in only four scans; the RT is nearly as good. The RI and the NNC require 2.5 or more scans beyond the MLI to obtain all four tracks, a delay which could have drastic consequences in a situation requiring quick response. The detection pattern in Table 6 indicates nearly perfect detection capability.

Table 1 — Far-Range Initiation Performance

Rep.	No. Tracks Initiated				Scans Required to Initiate							
	MLI		*RT*		*RI*				*NNC*			
	6 scans	8 scans	6 scans	8 scans	1 track	2 tracks	3 tracks	4 tracks	1 track	2 tracks	3 tracks	4 tracks
1	2	3	2	3	6	8	12	—	5	7	11	— (1 FT*)
2	3	3	3	3	4	7	22	45	5	13	19	— (2 FT*)
3	3	3	4	4	6	6	16	39	4	7	9	—
4	3	4	4	4	4	4	22	31	4	9	26	—
5	3(1 FT*)	3	3	3	4	4	10	23	4	7	12	21
6	4	4	3	3	4	5	12	25	4	4	12	34
7	3	3	2	2	4	5	26	37	4	8	23	— (1 FT*)
8	3	3	3	4	4	5	17	—	4	6	6	—
9	3	3	2	2	5	9	15	21	5	10	21	— (1 FT*)
10	3	3	4	3	4	11	16	26	4	4	18	— (1 FT*)
Av.	3	3.2	2.8	3.1	4.5	6.4	16.8	30.9†	4.3	7.5	15.7	27.5†

*False Track
†Average based on reduced number of repetitions

Table 2 — Detection Pattern (No. of Detections) in Far-Range Scenario

Scan	Repetition									
	1	2	3	4	5	6	7	8	9	10
1	2	1	2	4	4	3	1	2	2	2
2	2	2	3(FA*)	2	2	2	2	1	2	2
3	2(FA*)	2	1	2	3	3(FA*)	3(FA*)	3	1	2
4	2	3	2	3	2	3	2	3	2	4(FA*)
5	2	3	3	1	3(FA*)	3	2	1	2	0
6	2	1	3	2	2(FA*)	3	1	3	2	2(FA*)
7	1	2	3	1	2	2	2	3	3	0
8	4	1	0	4	3	2	2	0	2	0
9	4	2(FA*)	3	2	2	4	3	2	2	2
10	2(SP†)	2	3	2	3	2(FA*)	2	3	1	3
Av.	2.3	1.9	2.3	2.3	2.6	2.7	2.0	2.1	1.9	1.7

*False Alarm
†Split, two detections from one target

Table 3 — Pop-Up, Resolution Initiation Performance

Rep.	No. Tracks Initiated				Scans Required to Initiate							
	MLI		RT		RI				NNC			
	4 scans	5 scans	4 scans	5 scans	1 track	2 tracks	3 tracks	4 tracks	1 track	2 tracks	3 tracks	4 tracks
1	3	4	3	4	4	5	6	—	3	4	5	—
2	4	4	3	4	4	5	5	—	4	4	4	—
3	3	3	3	4	5	6	—	—	4	6	—	—
4	4	4	4	4	5	5	5	—	4	5	5	5
5	4	4	4	4	4	5	5	—	4	4	4	—
6	3	4	3	4	4	5	5	—	4	4	5	—
7	4	4	3	3	4	4	5	—	4	4	5	—
8	3	4	3	4	4	5	7	8	4	4	6	—
9	3	3	3	3	4	4	6	—	4	4	7	—
10	4	4	4	4	4	6	6	6	4	4	4	—
Av.	3.5	3.8	3.3	3.8	4.2	5.0	5.55*	7*	3.9	4.3	5*	5*

*Average based on reduced number of repetitions

Table 4 — Detection Pattern (No. of Detections) in Pop-Up, Resolution Scenario

Scan	Repetition									
	1	2	3	4	5	6	7	8	9	10
1	3	3	2	4	4	3	3	2	3	4
2	4	4	4	3	3	4	4	4	3	4
3	3	2	3	5 (FA*)	2	3	3	3	4	2
4	3	3	2	4	4 (FA*)	3	3	3	3	3
5	4	4	4	3	4	4	3	4	3	4
6	4	4	4	3	3	4	4	3	3	4
7	2	3	4	4	3	2	3	4	2	3
8	3	3	2	3	4 (FA*)	3	3	2	3	3
9	2	3	—	3	4	2	3	—	3	4
10	—	—	—	—	—	—	—	—	—	—
Av.†	3.1	3.2	3.1	3.6	3.4	3.1	3.2	3.1	3.0	3.4

*False Alarm
†Averages based on number of scans available

Table 5 — Pop-Up, Separated Initiation Performance

Rep.	No. Tracks Initiated				Scans Required to Initiate							
	MLI		RT		RI				NNC			
	4 scans	5 scans	4 scans	5 scans	1 track	2 tracks	3 tracks	4 tracks	1 track	2 tracks	3 tracks	4 tracks
1	4	4	4	4	4	4	4	4	4	4	4	7
2	4	4	4	4	4	5	5	9	4	4	4	9
3	4	4	4	4	4	5	5	7	4	4	4	5
4	4	4	4	4	5	5	6	7	4	5	6	8
5	4	4	4	4	5	5	6	6	4	5	5	5
6	4	4	4	4	4	4	5	5	4	4	4	4
7	4	4	4	4	5	5	7	7	4	4	4	9
8	4	4	5	4	4	5	5	6	4	5	5	7
9	4	4	4	4	4	5	5	6	4	4	5	7
10	4	4	4	4	4	4	5	6	4	4	4	5
Av.	4.0	4.0	4.1	4.0	4.3	4.7	5.4	6.55	4.0	4.3	4.5	6.6

Table 6 — Detection Pattern (No. of Detections) in Pop-Up, Separated Scenario

Scan	Repetition									
	1	2	3	4	5	6	7	8	9	10
1	4	4	4	3	4	4	4	5 (FA*)	4	3
2	4	4	4	4	3	4	4	4	4	4
3	4	4	4	4	4	4	3	4	4	4
4	4	3	4	5 (FA*)	4	4	3	4	4	4
5	4	3	4	4	4	5 (FA*)	3	4	4	4
6	4	4	4	4	4	4	4	4	4	4
7	3	4	4	4	4	3	4	4	4	4
8	3	4	3	5 (FA*)	4	3	4	3	4	5 (FA*)
9	4	4	—	5 (FA*)	4	4	5 (FA*)	—	4	4
10	—	—	—	—	—	—	—	—	—	—
Av.†	3.8	3.8	3.9	4.2	3.9	3.9	3.8	4.0	4.0	4.0

*False Alarm
†Averages based on number of scans available

5. CONCLUSIONS

For the three scenarios considered, the conventional Nearest Neighbor Correlator (NNC) has a slight edge over the Raid Initiator (RI) for the pop-up scenarios. But at far ranges the RI obtains more valid tracks and leads us to believe that if more rigorous criteria were imposed on the NNC to inhibit the initiation of false tracks, significant time delays would be introduced into the NNC relative to the RI.

However, the method of choice would seem to be the Raid Tracker (RT). The RT obtains results nearly equivalent to the Maximum Likelihood Initiator (MLI), the standard of comparison, and at a cost of only a minor increment of data storage to save the detection histories of candidate raids. The execution time of the RT should be of the same order as the NNC. The execution time of the MLI would be several orders of magnitude greater, much too long for real-time operation at the current capabilities of computational hardware.

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